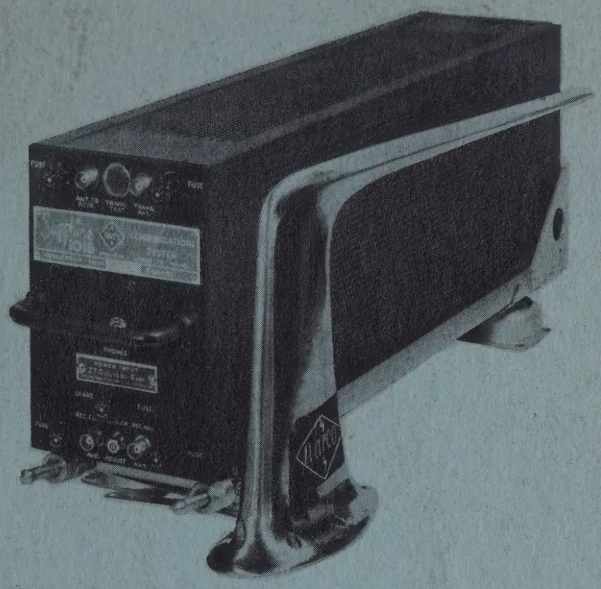
ISSUE No. 2 Feb. 1957



THE *narco* SAPPHIRE 1016 COMMUNICATIONS SYSTEM MODEL - VSC-I

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OPERATION and INSTALLATION MANUAL

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MANUFACTURED BY

NATIONAL AERONAUTICAL CORPORATION

COMMERCE DRIVE • FORT WASHINGTON • PENNSYLVANIA

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Perfection in Electronics

40-56

Price $1.00

Warranty

We have designed and constructed this equipment using the finest materials and components available. It has been thoroughly tested and inspected before leaving our factory.

NARCO warrants your new SAPPHIRE 1016 against all defects of workmanship and material on components and parts manufactured by us for a period of ninety (90) days from the date of installation. We will furnish a new part in exchange for any part which proves to be defective within this time under normal installation use and service provided you return the defective part, transportation charges prepaid, either to the factory or to our authorized warranty Service Center. To place your warranty in effect you must fill out the warranty card supplied with set and mail it to us within ten (10) days after your new installation is completed.

NATIONAL AERONAUTICAL CORPORATION
Fort Washington - Pennsylvania
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CAUTION

The VHF transmitter in this set is guaranteed to meet Federal Communication Commission approval only when NARCO crystals are used.

When ordering crystals for additional channels or replacements, state NARCO model number to insure getting properly correlated crystals.

Use of other than NARCO crystals will void manufacturer's warranty.

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SECTION I

INTRODUCTION and SPECIFICATIONS

A. PURPOSE:

The purpose of the NARCO SAPPHIRE 1016, Model VSC-1 Communications Equipment is to provide highly intelligible local or distant two way voice communication between aircraft and ground stations, or between aircraft.

B. GENERAL DESCRIPTION:

The equipment is designed to provide a minimum of 90 crystal controlled channels for both the transmitter and the receiver. The number of available channels can be increased to a maximum of 360 for the transmitter and a maximum of 560 for the receiver by the addition of suitable crystals.

Channel selection for both the transmitter and receiver is by means of a selector switch, or switches. When a single selector switch is provided both the transmitter and receiver are tuned simultaneously to the same channel or frequency, except when navigation frequencies below 118 mc. are provided for, and selected for the receiver. Such communication, with the transmitter and receiver tuned to the same channel, is known as "Simplex" operation. When separate selector switches are provided, the transmitter and receiver can be independently tuned to any channel provided. Such operation is known as "cross-channel" operation.

The channel selector switch or switches are mounted remotely from the equipment proper, and are wired to it. The typical selector switch has dual concentric knobs which are used to select the megacycle and fractional megacycle frequencies separately. The receiver and "Simplex" switches may be provided with a concentric volume control operated by a third knob.

The equipment proper consists of three major units, Transmitter, Receiver and Power Unit, in a "$\frac{1}{2}$ATR case", which fits a standard shockmount for a $\frac{1}{2}$ATR case. This equipment may be mounted in any remote location suitable for communication or navigation equipment and a source of DC power must be provided. The location should also, preferably, be near the antenna, to reduce transmission line losses.

The antenna to be used with this equipment for communication purposes must be essentially a vertically polarized broad band type, such as the NARCO Model VSAC-1. Since this antenna has a horizontal section, useful reception of the navigation frequencies between 108 and 118 megacycles will be provided. Most efficient reception of these navigation frequencies will be obtained by employing a separate horizontally polarized dipole.

C. SPECIFICATIONS:

C-1. Transmitter - A complete assembly of the transmitter is shown in Fig. 1.

a. Frequency Range

1. 90 channels
100 KC channel spacing
118.0 through 126.9 mc.

2. 360 channels
50 KC channel spacing
118.00 through 135.95 mc.

Conversion from 1 to 2 requires the wiring in of 10 additional "KC" crystals and plugging in of 9 additional "MC" crystals.

b. Frequency Stability
±0.01% by direct crystal control for all channels.

c. R.F. Power Output
5 to 7 watts nominal carrier power

d. Spurious Outputs
Not to exceed 50 microwatts

e. Modulation
Positive and negative speech modulation is provided. Over-modulation is prevented by both positive and negative limiting action. A speech amplifier adjustment is provided which may be adjusted so that up to 12 db compression is provided at full voice modulation, with input levels from typical aircraft microphones. Limiting takes place at approximately 85% modulation. Using this compression feature with a noise-cancelling microphone in a reasonably quiet aircraft, the average sideband power can be increased up to 16 times that obtainable without compression.

f. Sidetone
100 milliwatts from de-modulated r-f sampled output. This level may be pre-set to a level suitable for the particular installation.

C-2. Receiver - A complete assembly of the receiver is shown in Fig. 2.

a. Frequency Range

1. 90 channels
100 KC channel spacing
118.0 through 126.9 mc.

2. 560 channels
50 KC channel spacing
108.00 through 135.95 mc.

Conversion from 1 to 2 requires the wiring in of 10 additional "KC" crystals and plugging in of 18 additional "MC" crystals.

b. Sensitivity
100 milliwatts audio output at 2 microvolts r-f input, with a signal to noise ratio of 6 db.

c. Selectivity
34 KC minimum bandwidth at 6 db down points
67 KC maximum bandwidth at 60 db down points

d. Spurious Responses
60 db down

e. Audio output
Two outputs are provided. One output has an impedance of 300 ohms and is intended for use with one or two pairs of headphones. The second output has an impedance of 4 ohms and is intended for a loudspeaker. Nominal audio output is 3.0 watts. One or the other of the outputs should be terminated in a load of the corresponding impedance, but both outputs must not be terminated at the same time. It is customary to terminate the 4 Ohm speaker through a 4 ohm L pad and to use a bridging connection of the order of 5000 ohms on the 300 ohm winding by connecting 600 ohm headphones through a 5000 ohm potentiometer, if headphone operation is also required.

f. Audio Response
Within ± 3 db from 350 to 2500 c.p.s.

g. AVC (Automatic Volume Control) Characteristic
Within 4 db from 5 to 10,000 microvolts.

The time constant of the AVC circuit is automatically changed to suit OMNI signals on channels below 118.00 mc.

h. Noise Limiter
A series type noise limiter is provided.

i. Squelch
Automatic operating level is adjustable from 1 to 10 microvolts by means of an operating level adjustment available at the front panel of the main assembly. A headphone jack to monitor the audio signal while making the adjustment is also provided on this panel. Provision is also made for an external squelch deactivate button to test receiver operation.

j. OMNI Connections
A separate detector is provided with outputs for VOR and ILS connections. The connections are available at the connector for external connections on the shockmount assembly. A ground connection is made to activate the VOR on even tenths mc. from 108 through 111 mc. (TVOR) and 112 through 117 mc. (VOR).

C-3. Power Unit - A complete assembly of the power supply unit is shown in Fig. 3.

a. Vibrator
Non-synchronous, conservatively rated for long reliable life.

b. Power Transformer
Dual voltage design wired semi-permanently for either 13.75 or 27.5 volts DC operation.

c. Rectifiers
Selenium, of a high temperature design which will provide extremely long life.

d. Filters
Separate filters are provided for the various DC outputs to insure hum-free operation and avoid circuit interaction.

e. Relay
The power unit contains a four pole double throw relay which is normally operated by the "push-to-talk" button on the microphone. It performs all the switching operations for communication except for the antenna switching which is performed by a separate relay in the transmitter. This latter relay operates simultaneously with the power unit relay and is controlled by the same button or switch which controls the power unit relay.

C-4. Channel Selectors

a. Types
1. Cross-channel or duplex.
For this service, two separate switch assemblies are provided. The transmitter and receiver may be set independently to any channel provided in the equipment.

2. Simplex
a. For this service a single switch assembly is provided. It simultaneously tunes the transmitter and receiver to the same channel.

b. The channel selector mechanisms are automatic and the maximum time for channel selection is 2 seconds.

b. Special Features
1. Volume Control
A volume control with a concentric control shaft and knob can be provided on the receiver and simplex switches.

2. Stops
Stops in all the types of channel selector switches permit adjustment to the desired frequency ranges.

3. Scale Conversion
The scales on the "tenths" dials may be interchanged when conversion is made from 100 KC channels to 50 KC channels.

C-5. Antennas

a. Transmitter
Two BNC type connectors are provided. One is for connection to the communications antenna and the other is for connection to the receiver when a separate receiving antenna is not used. Switching is accomplished by a relay in the transmitter.

b. Receiver
Two BNC type connectors are provided. One is for communication frequencies and is connected to the receiver input whenever the receiver is on a communication frequency between 118 and 136 mc. The other is for navigation frequencies and is connected to the receiver input whenever the receiver is tuned to a navigation frequency between 108 and 118 mc.

c. Common Receiver Antenna
If no separate navigation antenna is provided, the two receiver connectors may be connected together with a T connector to a common antenna. The common antenna may be the communications antenna connected via the transmitter, or a separate antenna.

D. ENVIRONMENTAL:

Environmental Design Limits

a.	Temperature:	-40° C. to $+55^{\circ}$ C.
b.	Altitude:	0 to 30,000 feet without pressurization.
c.	Humidity:	0 to 95% relative.
d.	Vibration:	10 g. in any plane; 10 to 55 cycles.
e.	Shock:	15 g. (30 g. and remain attached).

E. POWER REQUIREMENTS:

E-1. Nominal 13.75 volts (12.4 minimum, 15.1 maximum) at 8 amps. receive; 12.5 amps. transmit.

E-2. Nominal 27.5 volts (24.8 minimum, 30.2 maximum) at 4 amps. receive; 6.3 amps. transmit.

F. WEIGHTS:

F-1. Transmitter-Receiver-Power Unit Assembly - 24.7 lbs.

F-2. Shockmount Assembly - 3.25 lbs.

F-3. Antenna - 2.8 lbs.

G. DIMENSIONS:

Transmitter-Receiver-Power Unit Assembly - $\frac{1}{2}$ATR unit 4-7/8" wide x 7-5/8" high x 19-9/16" long with a front projection of 1-1/2".

H. INSTALLATION:

All installation connections are made to a single Cannon type DPD-45-33S connector which is mounted on a rear bracket on the shock-mount assembly.

I. MAINTENANCE:

The main assembly consists of three plug-in independent major units, namely: Transmitter, Receiver and Power Unit. These units are quickly replaceable and may be independently bench tested. Units are completely interchangeable.

J. LICENSING:

The operation of the radio transmitter requires at least a third class radio-telephone operator's license which can be procured from any CAA flight examiner or FCC field office.

In addition, the transmitter itself as installed in the aircraft requires a station license. The technical details of this transmitter will be on file with the FCC so that all that is needed is to procure a copy of FCC form 404A which must be completed and forwarded to the FCC.

SECTION II

INSTALLATION

A. EQUIPMENT SUPPLIED:

VSC-1 Communication Equipment which is normally available in either 50 or 100 KC channel spacings as follows:

a. 100 KC Spacing
   1 VST-1 Transmitter - 90 channels (118.0 through 126.9 mc.)
   1 VSR-1 Receiver - 90 channels (118.0 through 126.9 mc.)
   1 VSP-1 Power Unit
   1 VSS-1 Shockmount Assembly

b. 50 KC Spacing
   1 VST-1 Transmitter - 360 channels (118.00 through 135.95 mc.)
   1 VSR-1 Receiver - 560 channels (108.00 through 135.95 mc.)
   1 VSP-1 Power Unit
   1 VSS-1 Shockmount Assembly

B. EQUIPMENT REQUIRED AND TO BE ORDERED SEPARATELY:

B-1. Channel Selector Switches are available in either simplex or cross channel styles.

a. Simplex Operation
   1. VSSC-1 Simplex Channel Selector
      Available with no volume control, with concentric headphone volume control, or with concentric loudspeaker volume control.

b. Cross Channel Operation
   1. VSRC-1 Receiver Channel Selector
      Available with no volume control, with concentric headphone volume control, or with concentric loudspeaker volume control.

   2. VSTC-1 Transmitter Channel Selector

B-2. Communications Antenna.

a. VSAC-1 Communications Antenna with mounting gasket.

C. EQUIPMENT REQUIRED BUT NOT SUPPLIED:

C-1. Antenna RF Cable to Transmitter.

a. RG-58A/U Coaxial Cable of suitable length to interconnect antenna and main unit.

b. One UG-88/U type BNC cable connector for each end of above cable.

C-2. RF Cables for interconnecting receiver and transmitter for common antenna.

a. For receiver operation on communication channels only (118.0 mc. and above).
1. RG-58A/U coaxial cable 9 inches long.

2. One BNC male connector plug (UG 88/U) for each end of above cable.

b. For receiver operation on both navigation and communication channels (both below and above 118.0 mc.). Two cables of Step 1 and 2 below required.
1. RG-58A/U coaxial cable 9 inches long.

2. One BNC male connector plugs (UG 88/U) for each end of above cable.

3. BNC type "T" connector, Amphonol No. 31-008 UG-274/U. One required.

C-3. Wire

a. For primary D.C. power line:
Minimum size #16 AWG for a total length of circuit (positive and ground) of not more than 6 feet for 13.75V conn. and not more than 12 feet for 27.50 V. conn. Larger wire sizes to be used as circuit length requires.

b. For control and auxiliary circuits:
Use #20 AWG or larger for any run up to 150 feet. Maximum number of circuits (wires) required without OMNI-NAVIGATION facilities is 31 plus the two primary D.C. wires under (a) above.

C-4. Microphone

a. Recommended is a close talking, noise cancelling type having a high speech articulation percentage under high ambient noise conditions. "Electro Voice Model L205KK" or equal is suggested. This suggested item contains a "Press-To-Talk" switch which is normally desired to operate the transmit-receive relays.

C-5. Headphones

a. The receiver headphone output circuit is designed to supply one or two pairs of headphones having an impedance of 600 ohms at 1000 cps.

C-6. Jacks

a. Microphone Jacks
The microphone jack must of course match the plug on the microphone which is usually provided with a three circuit plug having a sleeve diameter of approximately 3/16". Such plugs are accommodated by jacks such as the Switchcraft #12A, or equivalent.

NOTE: The microphone jack may require INSULATING WASHERS for mounting. This is to permit proper grounding at the transmitter to prevent possible noise pickup in the low level microphone circuit.

b. Headphone Jacks
The headphone jack or jacks must be chosen to match the plugs on the headphones which usually are a two circuit type having a sleeve diameter of approximately 1/4". A suitable jack is "Switchcraft #11", or equivalent. The headphone jack or jacks may be mounted with the frame or "ring" on a grounded panel, or may be insulated with the frame or "ring" grounded by the same circuit used to ground the microphone return. Noise conditions in the particular installation should govern the grounding arrangements.

For details of installation with both headphones and loudspeaker, refer to sub-section I, accessory installation, below.

C-7. Loudspeaker

The receiver loudspeaker output is designed to supply up to 3.5 watts to a 4 ohm load. A suitable speaker is "QUAM", PM-69A2, or equivalent, a 6" x 9" oval unit mounted in an appropriate baffle. If a speaker volume control is required, it should be in the form of a 4 ohm "L" or "T" pad. Other speakers having widely different impedances must be provided with suitable matching transformer. For details of installations with both headphones and loudspeaker, refer to sub-section I.

D. ACCESSORIES AVAILABLE:

D-1. Volume Control Kits.

a. M-54147-G101, for loudspeaker
1. Kit contains a 4 ohm "L" pad, knob and mounting hardware complete for assembly on VSSC-1 and VSRC-1 channel selector switches or instrument panel. Instructions are included.

b. M-54147-G102, for headphones
1. Kit contains a 5000 ohm potentiometer, knob and mounting hardware complete for assembly on VSSC-1 and VSRC-1 channel selector switches or instrument panel. Instructions are included.

D-2. Channel Selector Dial Conversion Kits.

a. K-54149-G101
1. Kit contains one 50 KC dial and is used to convert 100 KC selector switches to 50 KC selector switches.

b. K-54149-G102
   1. Kit contains one 100 KC dial and is used to convert 50 KC selector switches to 100 KC selector switches.

D-3. Crystal Kits.

a. P-54151-G102
   1. Kit contains 9 plug-in "megacycle" crystals for the transmitter and provides 127 through 135 mc. operation. It is used in converting a 90 channel transmitter to a 360 channel transmitter.

b. P-54151-G104
   1. Kit contains 19 plug-in "megacycle" crystals for the receiver and provides 108 through 117 and 127 through 135 mc. operation. It is used in converting a 90 channel receiver to a 560 channel receiver.

c. P-54151-G106
   1. Kit contains 10 wire-in "kilocycle" crystals for the transmitter and provides .05, .15, .25, .35, .45, .55, .65, .75, .85 and .95 mc. operation. It is used in converting a 90 channel transmitter to a 360 channel transmitter.

d. P-54151-G108
   1. Kit contains 10 wire-in "kilocycle" crystals for the receiver and provides .05, .15, .25, .35, .45, .55, .65, .75, .85 and .95 mc. operation. It is used in converting a 90 channel receiver to a 560 channel receiver.

e. P-54151-G109
   1. Kit contains all crystals described above in a, b, c and d and will provide all crystals required to convert a 90 channel transmitter to a 360 channel transmitter and a 90 channel receiver to a 560 channel receiver.

D-4. Antenna.

a. T-71144-G103
   1. Model VSAC-1 communications antenna with mounting gasket.

D-5. Channel Selector Switches.

a. P-61223-G101
   1. Model VSTC-1 transmitter channel selector for 100 KC channel spacing, without volume control.

b. P-61223-G102
   1. Model VSTC-1 transmitter channel selector for 50 KC channel spacing, without volume control.

c. P-61224-G101
   1. Model VSRC-1 receiver channel selector for 100 KC channel spacing, without volume control.

d. P-61224-G102
   1. Model VSRC-1 receiver channel selector for 50 KC channel spacing, without volume control.

e. P-61225-G101
   1. Model VSSC-1 simplex channel selector for 100 KC channel spacing, without volume control.

f. P-61225-G102
   1. Model VSSC-1 simplex channel selector for 50 KC channel spacing, without volume control.

E. PRIMARY POWER REQUIREMENTS:

E-1. Voltages and Currents.

a. Primary power is to be supplied from a single DC source having a nominal voltage of 13.75 or 27.5 volts D.C. Refer to Section I-E for voltage and current limits.

b. Regulation of the power supply system should be such that the maximum and minimum values referred to above are never exceeded while the equipment is in operation.

E-2. Switching and Circuit Protection.

a. No power control switch or primary circuit protection is provided within the equipment although two specific circuits within the power unit itself are protected by fuses (primary of vibrator transformer and bridge rectifier input). The four channel selector circuits are protected by individual fuses.

An external switch and fuse, or a circuit-breaker-switch should be provided if such circuitry is not already available in the aircraft.

Suitable ratings for switches and protective circuits may be determined from information under E-1 above.

F. MAIN ASSEMBLY WITH SHOCKMOUNT INSTALLATION:

F-1. Location, Weight and Size.

Refer to section I-B for location, I-F for weight and I-G for size.

F-2. Space Required and Wiring.

Installation dimensions and details of space required are given in the Fig. 4, Mounting and Outline Drawing. Note that the minimum clearance between equipments or equipment and surrounding enclosures should be two inches to provide proper sway space for the shockmounted assembly and ventilation. For information on wiring, refer to Section I-H.

G. ANTENNA INSTALLATION:

G-1. Location.

The antenna is designed for mounting on the outside surface of the aircraft in as unobstructed an area as possible. If possible, the location chosen should be at least five feet from other large projections on the aircraft in order to minimize radiation pattern distortion to the antenna.

G-2. Size.

Size, mounting dimensions and installation information for the antenna are given on the diagram Fig. 5.

G-3. Fittings, RF.

The antenna is fitted with a BNC type connector which is intended to protrude through a hole in the surface of the aircraft.

Connection to the antenna is made with a mating BNC connector attached to an RF cable. Refer to Section II-C.

H. CHANNEL SELECTOR INSTALLATION:

H-1. Location.

Either the single simplex switch assembly or the pair of switch assemblies for cross-channel operation may be mounted from the front or the rear of a panel.

H-2. Dimensions.

Information on mounting dimensions and circuit requirements is given on the diagram Fig. 6.

I. ACCESSORY INSTALLATION:

I-1. Microphone.

a. Information on a suitable microphone is given in Section II-C4.

b. The equipment is designed for the type of microphone which is fitted with a "push-to-talk" button. Connections for the relay circuits to be controlled by the microphone button are given on the diagram Fig. 6.

c. The speech level input to the transmitter is established by the output of the microphone. There is an adjustment in the transmitter, R-122, at the input to the speech amplifier to adjust the level from the particular type of microphone to be used to a suitable value for the transmitter. Once the level has been properly set, there is no need for further adjustment during the normal course of operation. Varying values of voice input are adequately taken care of by the highly effective speech compression feature of the speech amplifier.

d. Recommended grounding arrangement of the microphone circuit is given in Section II C-4.

I-2. Loudspeaker.

The audio power output amplifier will provide up to 3.5 watts of audio at an impedance level of 4 ohms. No manual output level control or adjustment is provided in the equipment. Audio output level is controlled over a very wide range of input signal by a highly effective AVC system. If a volume level adjustment is desired at the loudspeaker, it should be provided in the form of a 4 ohm "L" or "T" pad in order to maintain proper loading for the audio output amplifier. Connections for the speaker circuit are shown on the diagram Fig. 6.

I-3. Headphones.

The audio power output amplifier transformer is provided with a 300 ohm connection in addition to the 4 ohm output. It is intended for use with one or two pairs of 600 ohm phones. If no speaker is used and a volume control is desired, it should be in the form of a 300 ohm "L" or "T" pad.

If the headphones are to be used in addition to a loudspeaker, the termination should be in the loudspeaker circuit as under I-2 above and the headphones should be connected to the 300 ohm output by a bridging connection using a 5000 ohm potentiometer. Such a connection is indicated on the diagram Fig. 6.

I-4. Arrangement of Controls and Sidetone Level.

The volume control pad or potentiometer can be placed on the receiver or simplex channel selector switch assembly or on a panel. Sidetone output from a separate diode and amplifier coupled directly to the transmitter output is provided. It is connected to the headphone circuit during transmission by switching in the transmit-receive relay in the power unit. An adjustment at the sidetone amplifier input is provided to set the level to a suitable value for the headphones.

J. SQUELCH:

A "squelch circuit" is provided so that the receiver output can be cut off when the input signal is below a usable value. This prevents unnecessary noise when weak or no signals are being received. An adjustment is provided to set the minimum value of signal which will cause receiver output. It is a screwdriver adjustment located on the front panel of the main equipment assembly. To facilitate the adjustment, a headphone jack is provided near by on the panel.

K. INTERCOMMUNICATION:

No intercommunication circuits are provided within the equipment but the input and output circuits can be adapted to practically any desired arrangement.

A separate auxiliary distribution amplifier is usually provided when extensive intercommunication circuits are to be used.

L. ILLUMINATION:

The channel selector switch assemblies are provided with indirect lighting by means of a small lamp within the assembly. Circuits for the lamps are shown on the diagram Fig. 6.

SECTION III

OPERATION

Actual operation of a properly installed equipment is rather simple. The following outline is intended to facilitate normal operation.

A. PRIMARY POWER:

A-1. Power is normally applied by a single D.C line switch or circuit-breaker-switch.

A-2. Power should be applied after the aircraft electrical system is functioning with proper voltage regulation.

A-3. A warmup time of at least several minutes should be permitted whenever possible.

B. TRANSMITTER:

B-1. The proper channel on which it is desired to transmit is selected by either the transmitter channel selector switch or the simplex channel selector switch, depending on the installation. Channel selection is completed within two seconds for any given setting.

B-2. Activation of the transmitter is normally instigated by pushing the "push-to-talk" button on the microphone. The "push-to-talk" button operates two relays. One in the transmitter connects the transmitter RF output to the antenna. The other in the power unit makes the proper DC supply voltage connections to the transmitter and connects the monitoring sidetone from the transmitter output to the headphone circuits.

B-3. Best results are obtained by speaking in a normal voice close to the microphone.

C. RECEIVER:

C-1. The proper channel on which it is desired to receive is selected by either the receiver channel selector switch or the simplex channel selector switch, depending on the installation. Channel selection is completed within two seconds for any given setting.

C-2. Volume output from the receiver is controlled over a very wide range of input signal level by means of a highly effective AVC (Automatic Volume Control) system. Output level settings may be made for a loudspeaker or headphones, depending on the provisions of the particular installation.

C-3. A "squelch" circuit is provided to cut off the receiver output when no signal is being received or when the signal is below a usable level. The signal level at which the receiver output is activated may be pre-set in accordance with instructions given in section II-J. In order to test for receiver operation, when no signal is being received, a circuit is provided to deactivate the squelch circuit. This is usually in the form of a momentary contact push button. When the squelch circuit is deactivated and no signal is being received, a normal amount of background noise will indicate that the receiver is functioning properly.

D. OTHER ACCESSORIES:

If other equipment, such as intercommunication circuits or auxiliary amplifying equipment is provided, separate instructions should be available for their operation.

SECTION IV

BASIC CIRCUIT DESCRIPTION

A completely assembled SAPPHIRE 1016 Communications Unit, outside of the dust cover, is shown in Fig. 7. The unit is shown in the upright position. The receiver unit occupies the lower left hand portion of the assembly. Directly to the rear of the receiver unit is the power unit. The transmitter unit sets directly atop of both the receiver and power units, completely covering the receiver unit and partially covering the power unit. A disassembled view of Fig. 7 is shown in Fig. 8.

In the description which follows, parts are identified by symbol number. Reference should be made to Schematic Diagrams Figures 9, 10 and 11 covering the power unit, transmitter and receiver respectively. Symbols in the 100 series are in the transmitter, 200 series in the receiver and 400 in the power unit.

A. PRIMARY POWER:

Upon closing the external equipment power switch, power is applied to the coil of vibrator, E-401 and on 27.5 volt operation through a time delay circuit R-411 and C-413 to start relay K-402, the contacts of which operate a fraction of a second later. When the contacts of K-402 operate, power is connected to the power contacts of vibrator E-401 and to the vibrator power transformer T-401 and to all tube filaments, transfer relays, microphone polarization and control switch circuits. The delay on 27.5 volt operation in applying power to the contacts of the vibrator is to permit its vibrating reed to come up to normal vibration amplitude and rate under no load conditions in order to provide the maximum possible vibrator life.

The AC voltage developed in the secondary of transformer T-401 is rectified by two bridge connected rectifiers, CR-401 and CR-402. Their D.C outputs after passing through the contacts of send-receive actuated relay K-401 are distributed to the transmitter or receiver depending whether reception or transmission is desired.

B. TRANSMITTER:

The output frequency of the transmitter is the sum frequency of two oscillators.

The h-f oscillator, V-102, is a crystal controlled Butler type. The second harmonic output of this oscillator push-push feeds the balanced mixer stage V-103. The l-f oscillator, V-101, is a crystal controlled Colpitts type. The fundamental frequency output of the oscillator push-pull feeds the balanced mixer stage V-103.

The sum frequency output of the mixer stage, V-103, corresponding to output frequency of the transmitter is amplified in the push-pull buffer amplifier stage V-104, which drives the push-pull final amplifier stage V-105. The output of the final stage is link coupled to an RF band pass filter, Z-102, which includes a send-receive relay, K-103, the output of which connects to the coaxial antenna connector J-102.

Audio from an external microphone passes through microphone transformer T-10, through a gain control potentiometer R-122, and through the speech amplifier, V-106A. Transformer, T-102, converts the single ended output of V-106-A to push-pull drive to the modulator stage, V-107. The output of the modulator passes through the modulation transformer T-103 to plate and screen modulate the final r-f amplifier V-105. The limiting action is provided in the modulator stage.

A small amount of the modulated r-f energy appearing at the input of the r-f band pass filter, Z-102, is coupled to a sidetone detector XT-139 and through sidetone volume control R-138 to the sidetone amplifier V-106-B. The output of this amplifier is transformer coupled to the external headphone circuit when transmitting.

The h-f oscillator (V-102) plug-in crystals XT-101 through XT-118 and its associated tuned circuits as well as those of V-103, V-104 and V-105 are selected or tuned by the "mc" Ledex Z-103 which is remotely controlled by the mc. dial of the control switch assembly. It retunes the transmitter in 1 megacycle steps.

The 1-f oscillator (V-101) wire-in crystals XT-119 through XT-138 are selected by the "kc" Ledex Z-104. In addition, the Ledex Z-104 by means of a mechanical differential retunes the tuned circuits of V-103, V-104 and V-105. It retunes the transmitter in either 50 or 100 kc steps, depending on the model.

The control switch assemblies energize control relays K-101 and K-102, which in turn energize the coils of Ledex assemblies Z-103 and Z-104 so that the heavy currents drawn by the Ledex coils are confined to short heavy leads within the equipment proper.

C. RECEIVER:

An RF signal enters the receiver at coaxial connectors J-201 or J-202 (J-201 for frequencies of 118.00 and above and J-202 for frequencies below 118.00). The signal then passes through a cascode type of r-f amplifier, V-201. The amplified r-f signal then is converted by the first mixer, V-202, into high frequency i-f.

The oscillator injection voltage for the first mixer is generated in the h.f. oscillator, V-203. This oscillator is a Butler type and is crystal controlled. The injection voltage is the second harmonic of this oscillator.

The difference frequency between the signal and the h.f. oscillator is amplified in the fixed-tuned one-stage band-pass high frequency i-f amplifier, V-204, covering 51.0 to 52.0 mc. The output of V-204 feeds the second mixer V-205.

The second mixer is of the balanced type. The oscillator injection voltage for the second mixer is generated in the 1-f oscillator, V-206. This oscillator is a Butler type and is crystal controlled. The injection voltage is at the fundamental frequency of this oscillator and is cathode injected into the mixer.

The difference frequency between the h-f i-f output and the 1-f oscillator is passed by the second mixer, V-205, into the three stage 1-f, i-f amplifier comprising V-207, V-208 and V-209. The output of the third stage, V-209, energizes two detectors V-210-A and V-211-A.

Detector V-210-A, a triode grid bias detector, provides output to the VOR/LOC terminal for use by auxiliary navigation equipment. The audio output of diode detector V-211-A energizes the noise limiter V-211-B. The audio output of V-211-B is amplified by V-210-B provided its level overcomes the squelch level produced by V-212-A. The output of amplifier V-210-B energizes the audio output stage V-213, the output of which feeds the external loudspeaker and headphone circuits.

The output of the third 1-f i-f amplifier stage, V-209, also energizes the AVC amplifier V-212-B.

The h-f oscillator (V-203) plug-in crystals, XT-201 through XT-228, and its tuned circuits as well as the tuned circuits of the r-f amplifier V-201 are selected by the "mc" Ledex Z-201 which is remotely controlled by the mc. dial of the control switch assembly. It retunes the receiver in 1 megacycle steps. Automatic selection is also made of r-f input connector, AVC time constant, and navigation band/communication band audio level.

The 1-f oscillator (V-206-A) wire-in crystals, XT-229 through XT-248 are selected by the "kc" Ledex Z-202 which is remotely controlled by the kc dial of the control switch assembly. It retunes the receiver in either 50 or 100 kc steps, depending on the model.

The control switch assemblies energize control relays RY-201 and RY-202, which in turn energize the Ledex coils Z-201 and Z-202 so that the heavy currents drawn by the Ledex coils are confined to short heavy leads within the equipment proper.

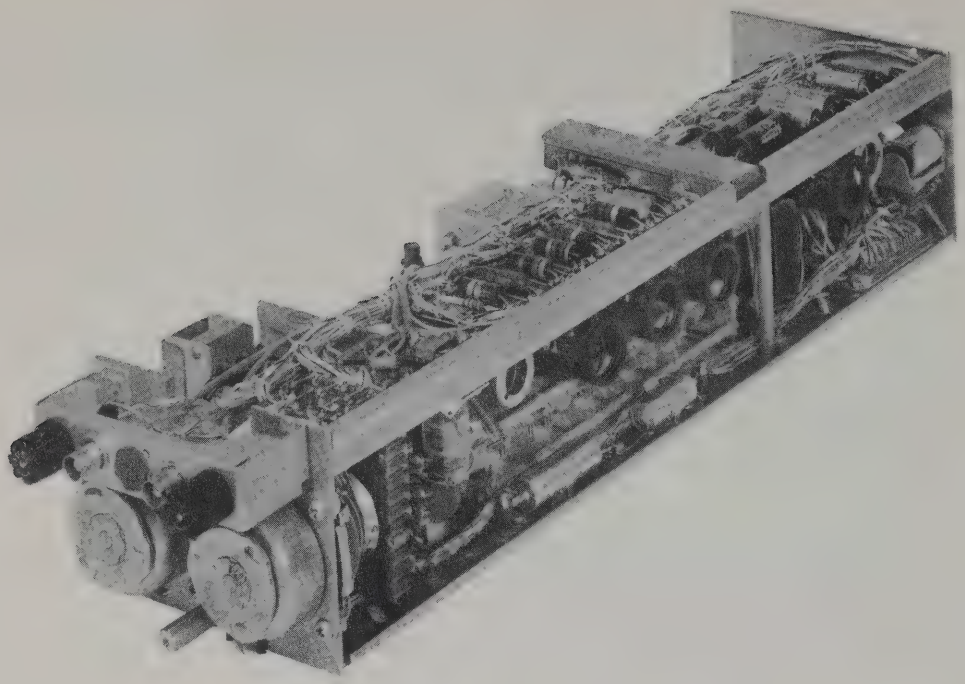


Figure 1

TRANSMITTER UNIT
SAPPHIRE 1016 EQUIPMENT

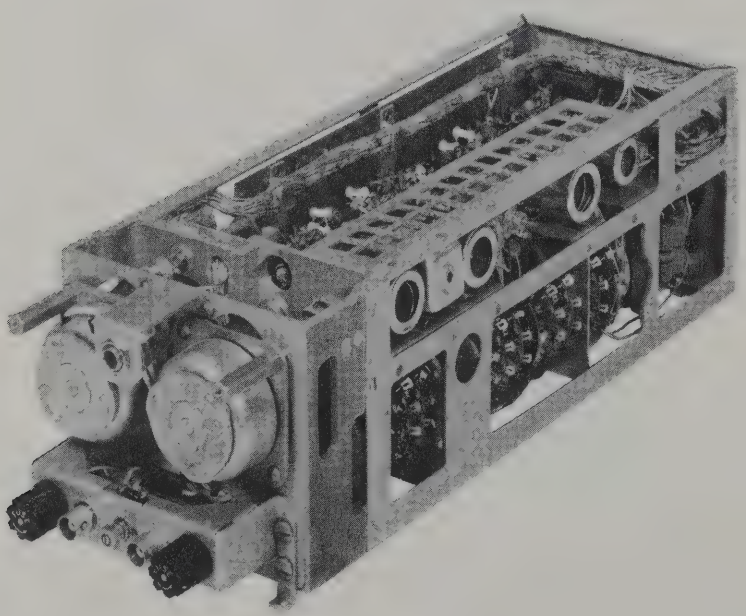


Figure 2

RECEIVER UNIT
SAPPHIRE 1016 EQUIPMENT

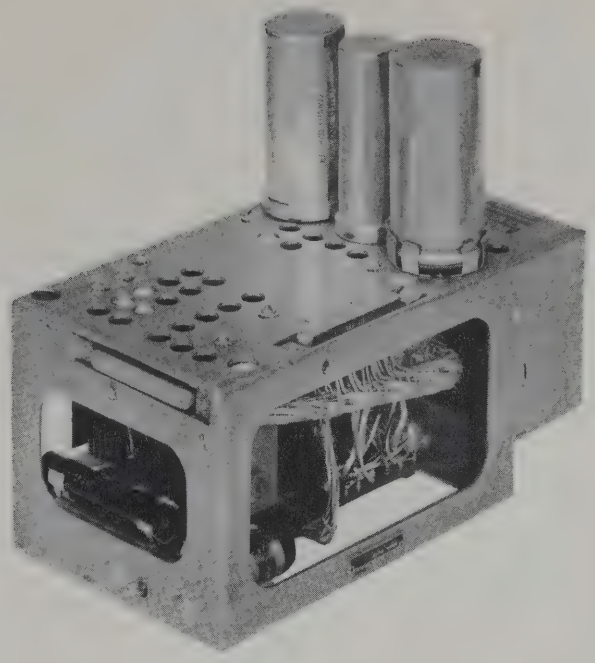
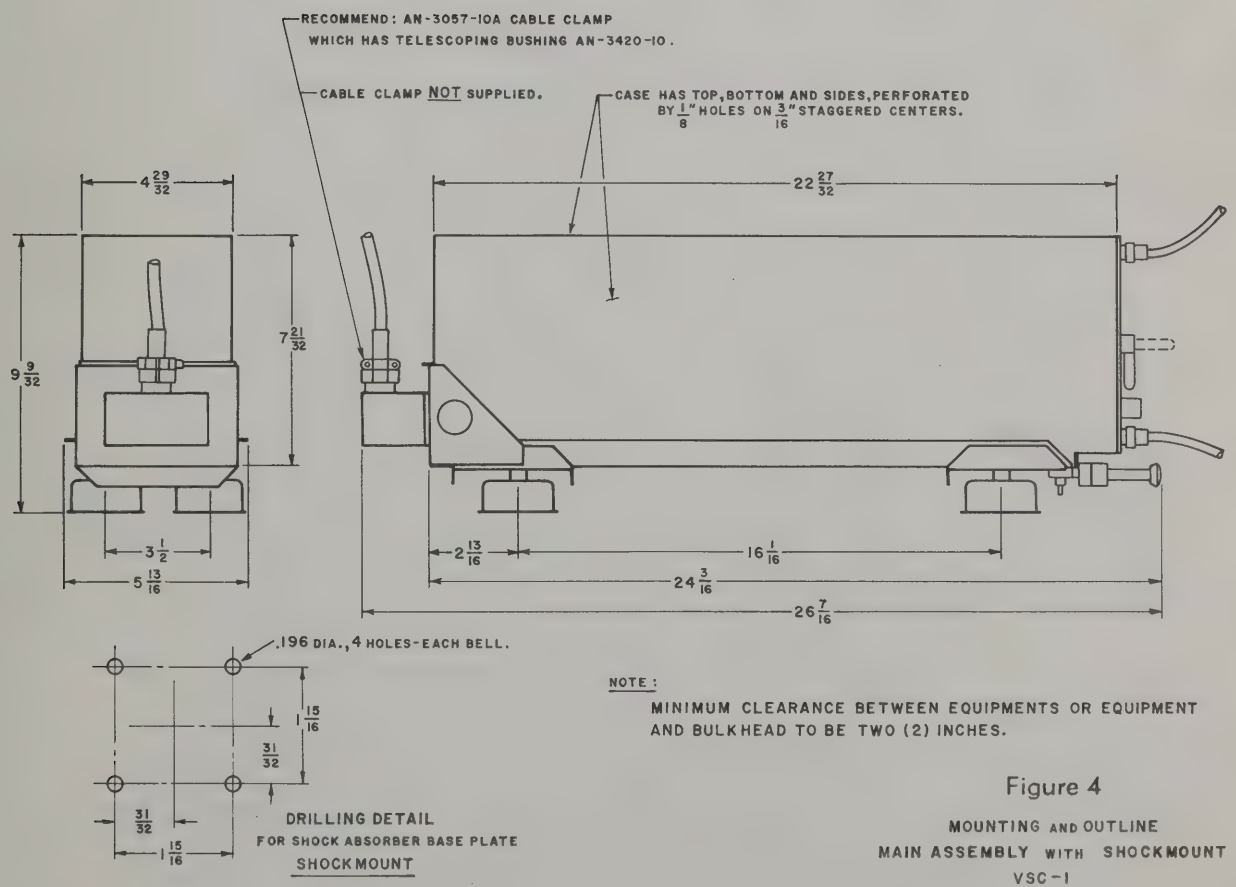


Figure 3

POWER UNIT
SAPPHIRE 1016 EQUIPMENT



NOTE:

MINIMUM CLEARANCE BETWEEN EQUIPMENTS OR EQUIPMENT AND BULKHEAD TO BE TWO (2) INCHES.

Figure 4

MOUNTING AND OUTLINE
MAIN ASSEMBLY WITH SHOCKMOUNT
VSC-1

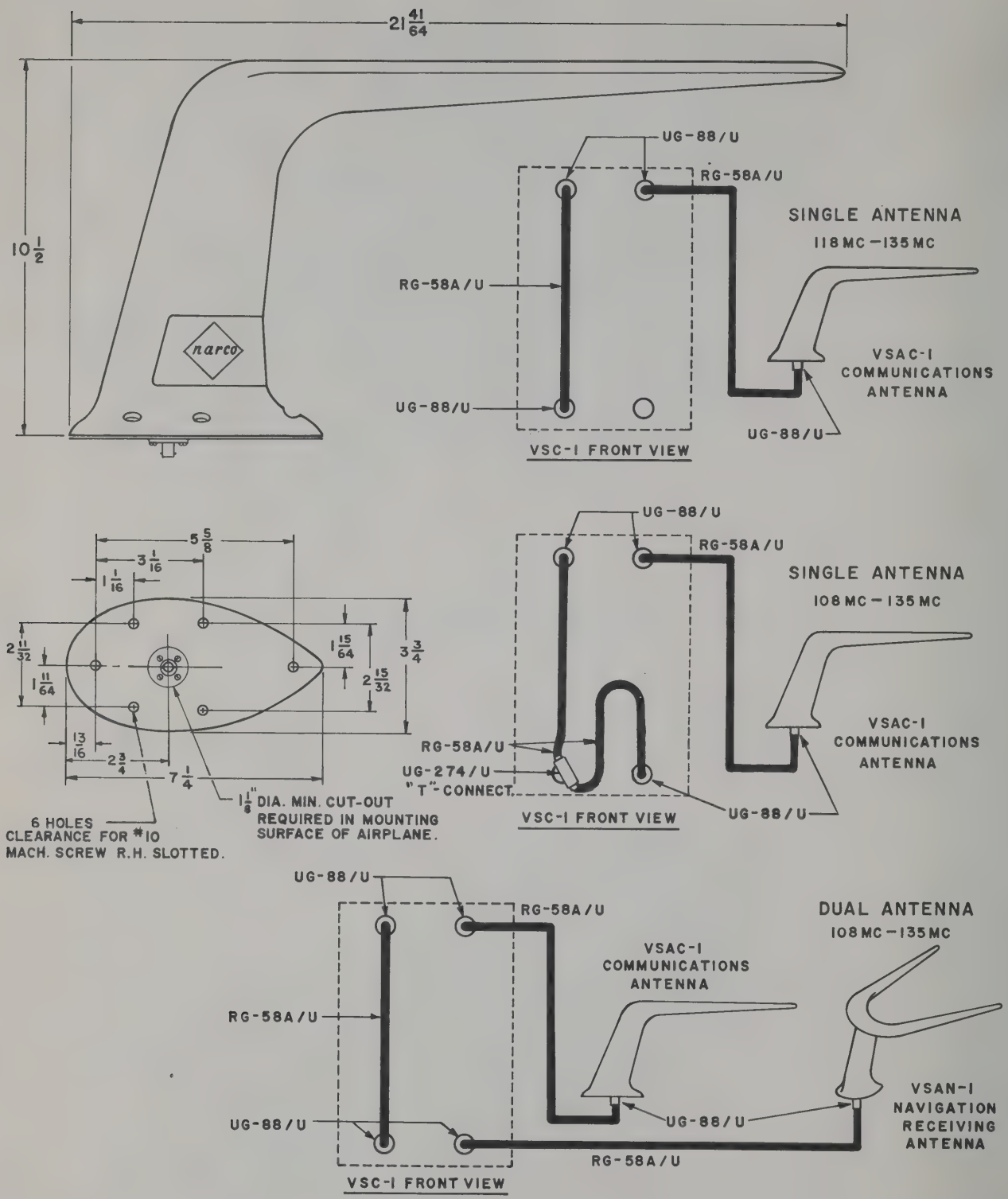
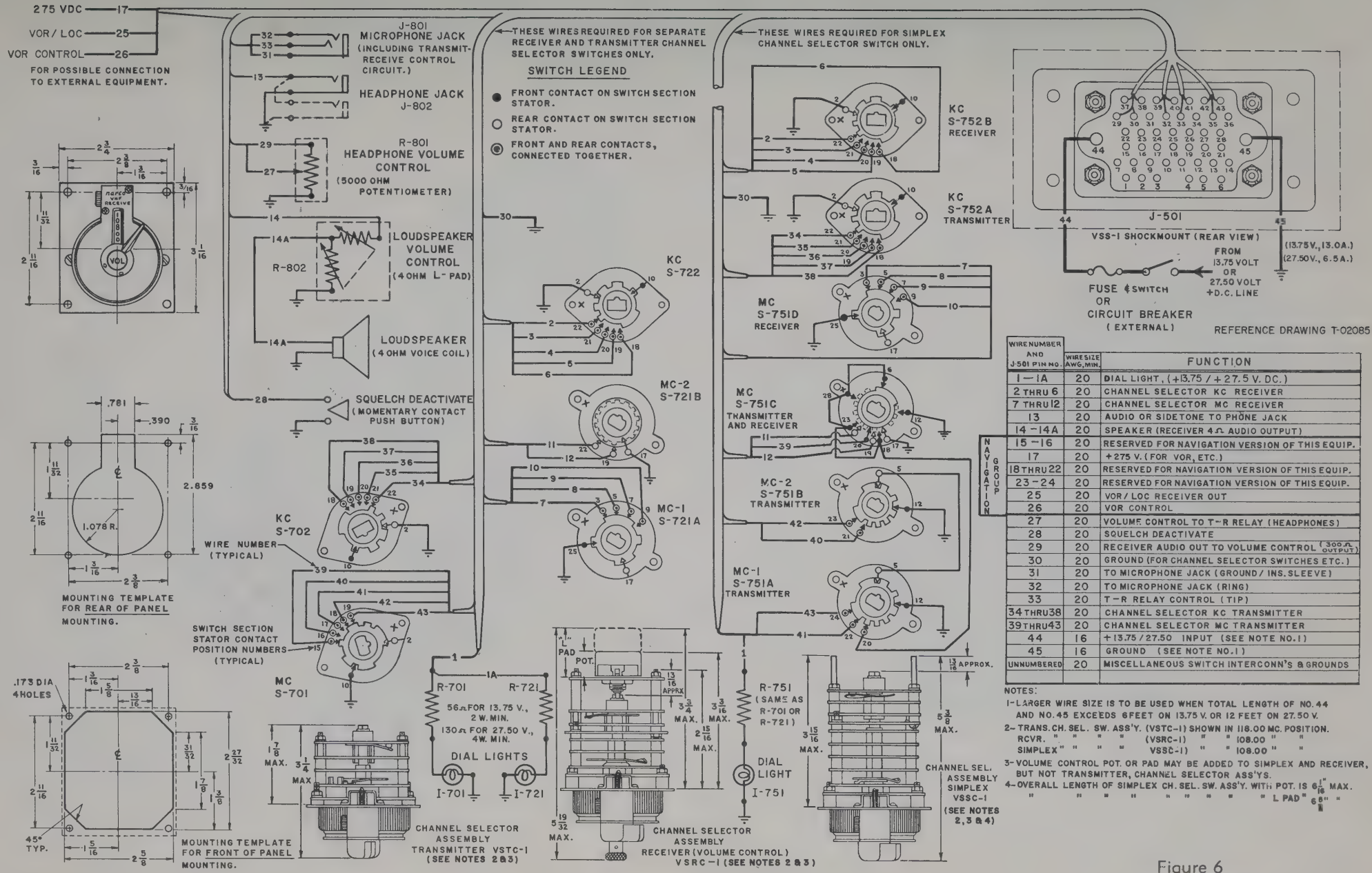


Figure 5

ANTENNA
INSTALLATION AND INTERCONNECTIONS
FOR VSC-1 EQUIPMENT


275 VDC — 17
VOR/LOC — 25
VOR CONTROL — 26
FOR POSSIBLE CONNECTION TO EXTERNAL EQUIPMENT.
J-801 MICROPHONE JACK (INCLUDING TRANSMIT-RECEIVE CONTROL CIRCUIT.)
HEADPHONE JACK J-802
R-801 HEADPHONE VOLUME CONTROL (5000 OHM POTENTIOMETER)
R-802 LOUDSPEAKER VOLUME CONTROL (4 OHM L-PAD)
LOUDSPEAKER (4 OHM VOICE COIL)
SQUELCH DEACTIVATE (MOMENTARY CONTACT PUSH BUTTON)
THESE WIRES REQUIRED FOR SEPARATE RECEIVER AND TRANSMITTER CHANNEL SELECTOR SWITCHES ONLY.
SWITCH LEGEND
FRONT CONTACT ON SWITCH SECTION STATOR.
REAR CONTACT ON SWITCH SECTION STATOR.
FRONT AND REAR CONTACTS, CONNECTED TOGETHER.
THESE WIRES REQUIRED FOR SIMPLEX CHANNEL SELECTOR SWITCH ONLY.
KC S-752B RECEIVER
KC S-752A TRANSMITTER
KC S-722
MC S-751D RECEIVER
MC-2 S-721B
MC S-751C TRANSMITTER AND RECEIVER
MC-1 S-721A
MC-2 S-751B TRANSMITTER
MC-1 S-751A TRANSMITTER
KC S-702
MC S-701
WIRE NUMBER (TYPICAL)
SWITCH SECTION STATOR CONTACT POSITION NUMBERS (TYPICAL)
J-501
VSS-1 SHOCKMOUNT (REAR VIEW)
FROM 13.75 VOLT OR 27.50 VOLT +D.C. LINE
(13.75V., 13.0A.)
(27.50V., 6.5A.)
FUSE & SWITCH OR CIRCUIT BREAKER (EXTERNAL)
REFERENCE DRAWING T-02085
MOUNTING TEMPLATE FOR REAR OF PANEL MOUNTING.
MOUNTING TEMPLATE FOR FRONT OF PANEL MOUNTING.
R-701
R-721
56Ω FOR 13.75 V., 2 W. MIN.
130Ω FOR 27.50 V., 4W. MIN.
DIAL LIGHTS
I-701
I-721
PAD
POT.
R-751 (SAME AS R-701 OR R-721)
DIAL LIGHT I-751
CHANNEL SELECTOR ASSEMBLY TRANSMITTER VSTC-1 (SEE NOTES 2&3)
CHANNEL SELECTOR ASSEMBLY RECEIVER (VOLUME CONTROL) VSRC-1 (SEE NOTES 2&3)
CHANNEL SEL. ASSEMBLY SIMPLEX VSSC-1 (SEE NOTES 2,3&4)
NAVIGATION GROUP

WIRE NUMBER AND J-501 PIN NO.	WIRE SIZE AWG, MIN.	FUNCTION
1 — 1A	20	DIAL LIGHT, (+13.75 / +27.5 V. DC.)
2 THRU 6	20	CHANNEL SELECTOR KC RECEIVER
7 THRU 12	20	CHANNEL SELECTOR MC RECEIVER
13	20	AUDIO OR SIDETONE TO PHONE JACK
14 — 14A	20	SPEAKER (RECEIVER 4Ω AUDIO OUTPUT)
15 — 16	20	RESERVED FOR NAVIGATION VERSION OF THIS EQUIP.
17	20	+275 V. (FOR VOR, ETC.)
18 THRU 22	20	RESERVED FOR NAVIGATION VERSION OF THIS EQUIP.
23 — 24	20	RESERVED FOR NAVIGATION VERSION OF THIS EQUIP.
25	20	VOR/LOC RECEIVER OUT
26	20	VOR CONTROL
27	20	VOLUME CONTROL TO T-R RELAY (HEADPHONES)
28	20	SQUELCH DEACTIVATE
29	20	RECEIVER AUDIO OUT TO VOLUME CONTROL (300Ω OUTPUT)
30	20	GROUND (FOR CHANNEL SELECTOR SWITCHES ETC.)
31	20	TO MICROPHONE JACK (GROUND/INS. SLEEVE)
32	20	TO MICROPHONE JACK (RING)
33	20	T-R RELAY CONTROL (TIP)
34 THRU 38	20	CHANNEL SELECTOR KC TRANSMITTER
39 THRU 43	20	CHANNEL SELECTOR MC TRANSMITTER
44	16	+13.75/27.50 INPUT (SEE NOTE NO.1)
45	16	GROUND (SEE NOTE NO.1)
UNNUMBERED	20	MISCELLANEOUS SWITCH INTERCONN'S & GROUNDS

NOTES:
1- LARGER WIRE SIZE IS TO BE USED WHEN TOTAL LENGTH OF NO. 44 AND NO. 45 EXCEEDS 6 FEET ON 13.75 V. OR 12 FEET ON 27.50 V.
2- TRANS. CH. SEL. SW. ASS'Y. (VSTC-1) SHOWN IN 118.00 MC. POSITION.
RCVR. " " " " (VSRC-1) " " 108.00 " "
SIMPLEX " " " " VSSC-1) " " 108.00 " "
3- VOLUME CONTROL POT. OR PAD MAY BE ADDED TO SIMPLEX AND RECEIVER, BUT NOT TRANSMITTER, CHANNEL SELECTOR ASS'YS.
4- OVERALL LENGTH OF SIMPLEX CH. SEL. SW. ASS'Y. WITH POT. IS 6 1/16" MAX.
" " " " " " " " " L PAD" 6 5/8" "

Figure 6

CHANNEL SELECTORS
INSTALLATION INTERCONNECTIONS
FOR VSC-1 EQUIPMENT

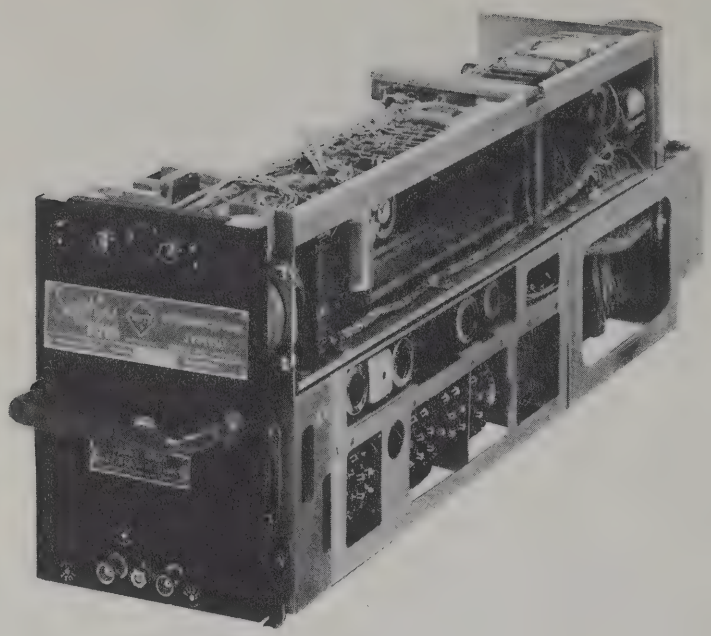


Figure 7

MAIN ASSEMBLY WITH CASE REMOVED
SAPPHIRE 1016 EQUIPMENT

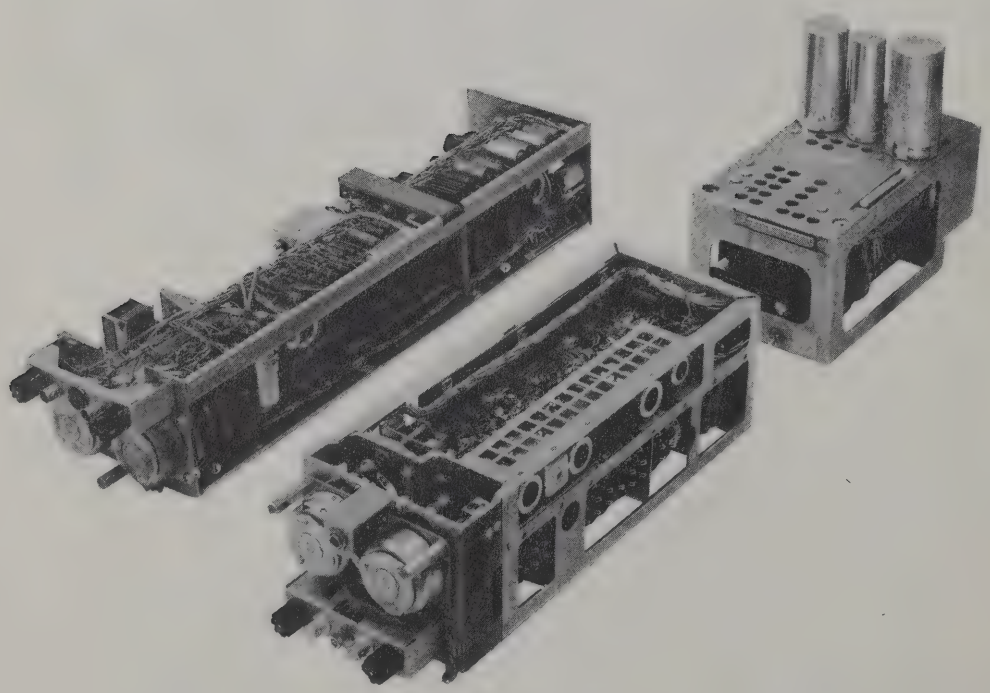
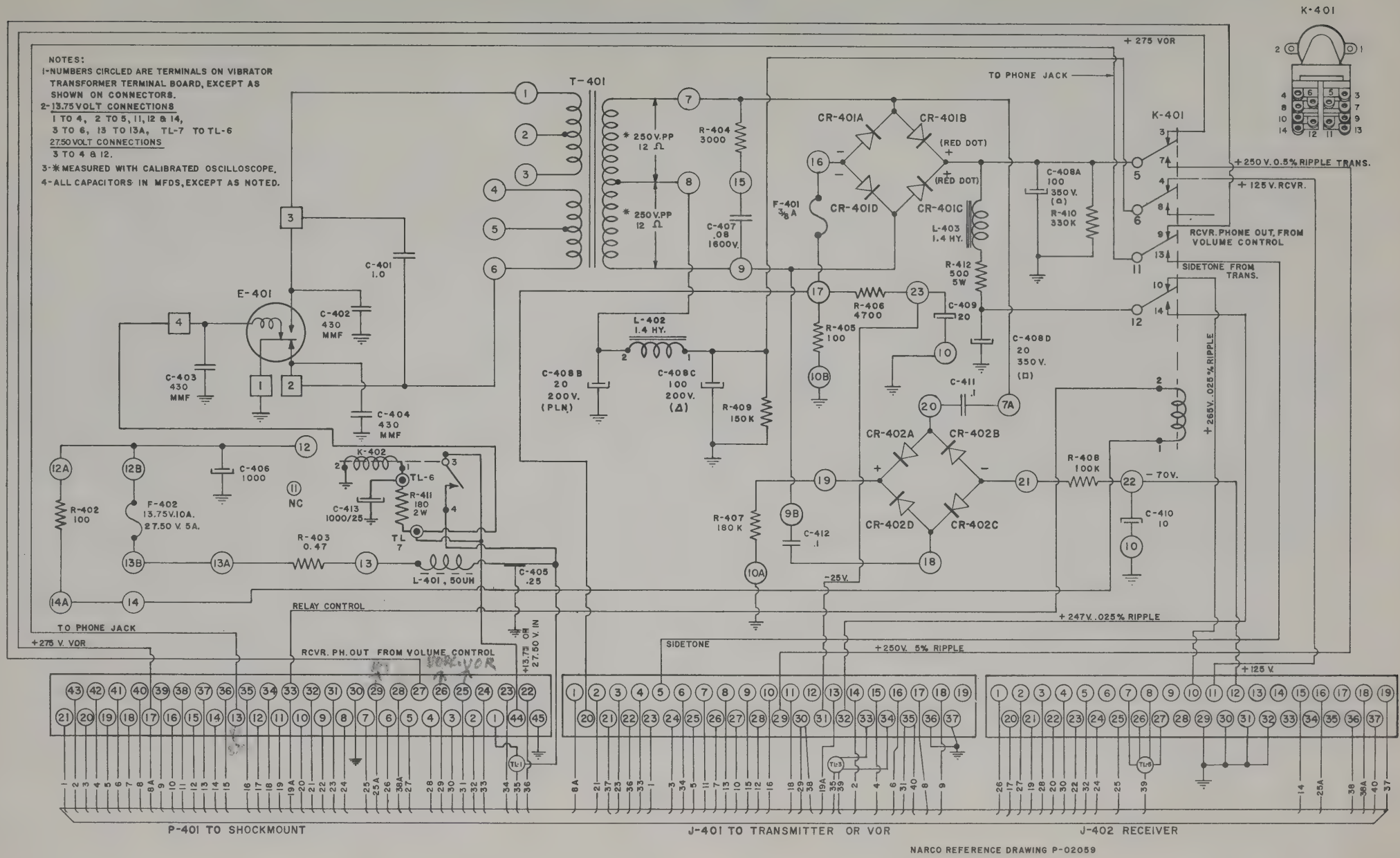


Figure 8

TRANSMITTER, RECEIVER & POWER UNIT ASSEMBLIES
SAPPHIRE 1016 EQUIPMENT



NARCO REFERENCE DRAWING P-02059

Figure 9

SCHEMATIC
POWER UNIT, VSP—1

LEDEX ASSEMBLY-Z-103
MC. LEDEX COIL
R-154 1Ω 10W
13.75 V. OPERATION
R-155 1Ω 10W
27.50 V. OPERATION
13.75 V. OPERATION
C-102 10MFD 150V.
61.005 TO 52.505 MC. IN .500 MC. INTERVALS
2:1 GEAR RATIO
MECH. DIFF.
105.01 TO 122.01 MC.
S-105
5670 H.F. OSC. V-102
S-102
L-122 2.2μH
ROTATION
L-123 .47μH
C-106 1000
R-103 1000
R-104 1800
S-101 MC. WAFER
S-103
XT 118
XT 117
XT 116
XT 103
XT 102
XT 101
C-108 4.7 N750
C-109 22
L-124
C-107 .5 TO 4.5
L-125
L-126
C-110 .5 TO 4.5
C-111 200
C-116 .5 TO 4.5
C-117 5
C-114A
L-130 2.2μH.
R-115 12K
C-127 220
R-114 15K
C-128 .01
R-116 12K
R-117 100
L-131 2.2μH
C-118 5
R-106 39K
R-107 2.2K
C-112 1500
K-101
A5
13.75V. OPER.
A3
R-101 100 3W
F-101
C-105 1500
L-101 L-102 L-103 L-104 L-105 L-106 L-107 L-108 L-109 L-110 L-111 L-112 L-113 L-114 L-115 L-116 L-117
S-104
R-150 47
R-105 7K 5W
ROTATION
6AK5 OR 5654 L.F. OSC. V-101
BAND PASS FILTER 12.7 TO 14.3 MC. Z-101
L-128
L-129
C-125 12
C-119 22
C-124 33
C-122 .0047
C-120 100
R-108 47K
L-127 39μH
R-110 47K
C-123 .0047
R-111 22K 2W
C-126 .01
C-180 2 MMF
Z-104 LEDEX ASSEMBLY
R-156 1Ω 10W
R-157 1Ω 10W
13.75 V. OPERAT'N
27.50V. OPERAT'N
13.75V OPERAT'N
KC. LEDEX COIL
C-103 10MFD 150V
S-107
XT-138 XT-137 XT-136 XT-135 XT-134 XT-133 XT-132 XT-131 XT-130 XT-129 XT-128 XT-127 XT-126 XT-125 XT-124 XT-123 XT-122 XT-121 XT-120 XT-119
S-106 KC. WAFER
C-121 .01
R-109 15K
K-102
13.75V. OPER.
R-102 100 3W
F-102
12,990 TO 13,940 MC. CRYSTALS IN .050 MC. INTERVALS.
MC. CONTROL
KC. CONTROL
RECEIVER MUTE
ANTENNA RELAY
MIC. RING
MIC.
SIDETONE
+250 V. 5% RIPPLE
+13.75V OR 27.50V.
-25 V. BIAS
GND.
247 V. .025% RIPPLE
-25 V. BUFFER & MOD. BIAS
SWITCH LEGEND
● - FRONT CONTACTS
○ - REAR CONTACTS
◉ - FRONT AND REAR CONTACTS
REAR CONTACTS AND RINGS
SHOWN IN DOTTED LINES.
NOTE:
SWITCHES ARE SHOWN GIVI
OPERATING FREQUENCY OF
21 11 10 9 8 7 18 17 16 15 14 13 2 3 5 29 33 34 31 36 37 32 20
POWER PLUG—P-101
REFERENCE DRAWING T-02056

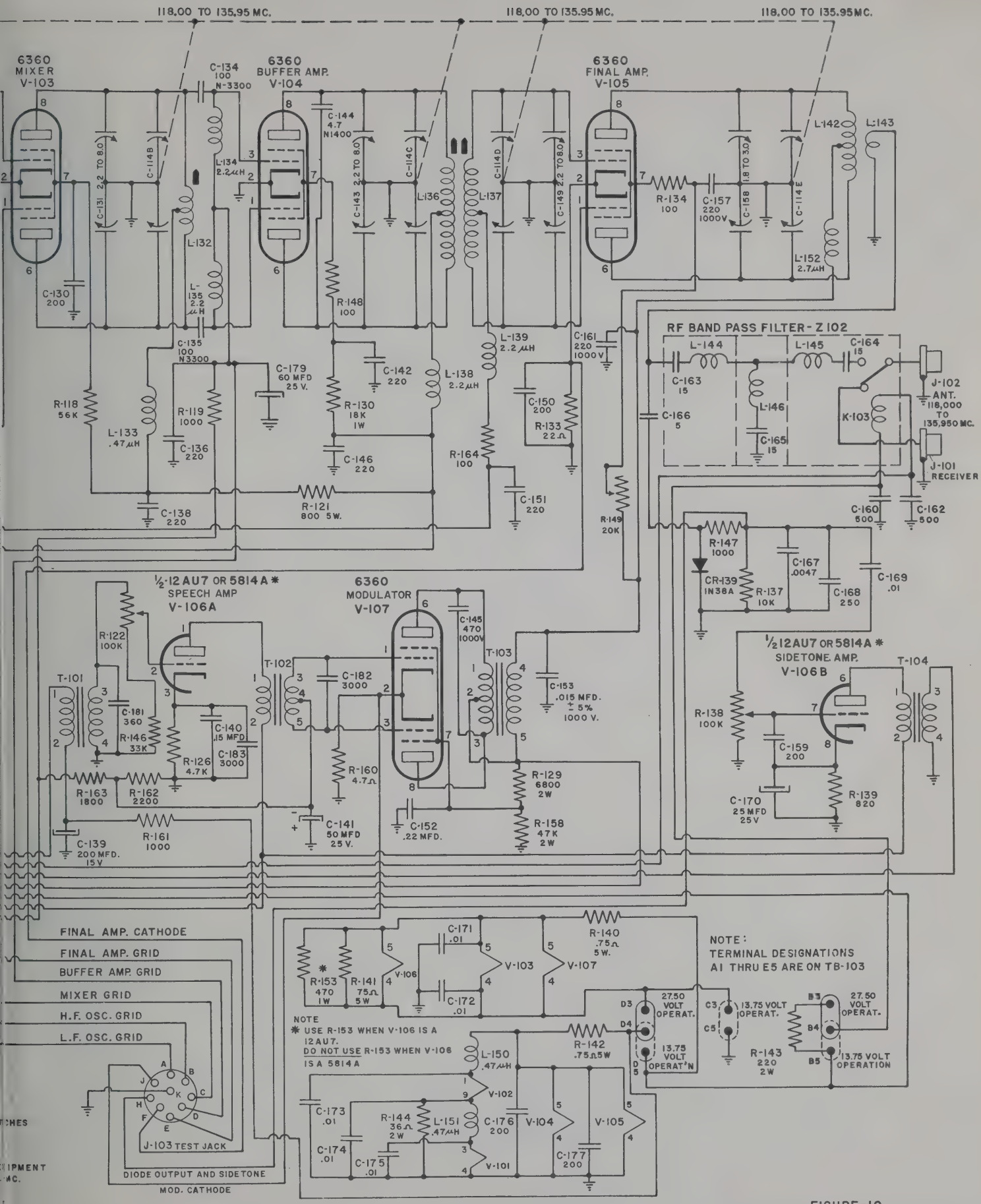
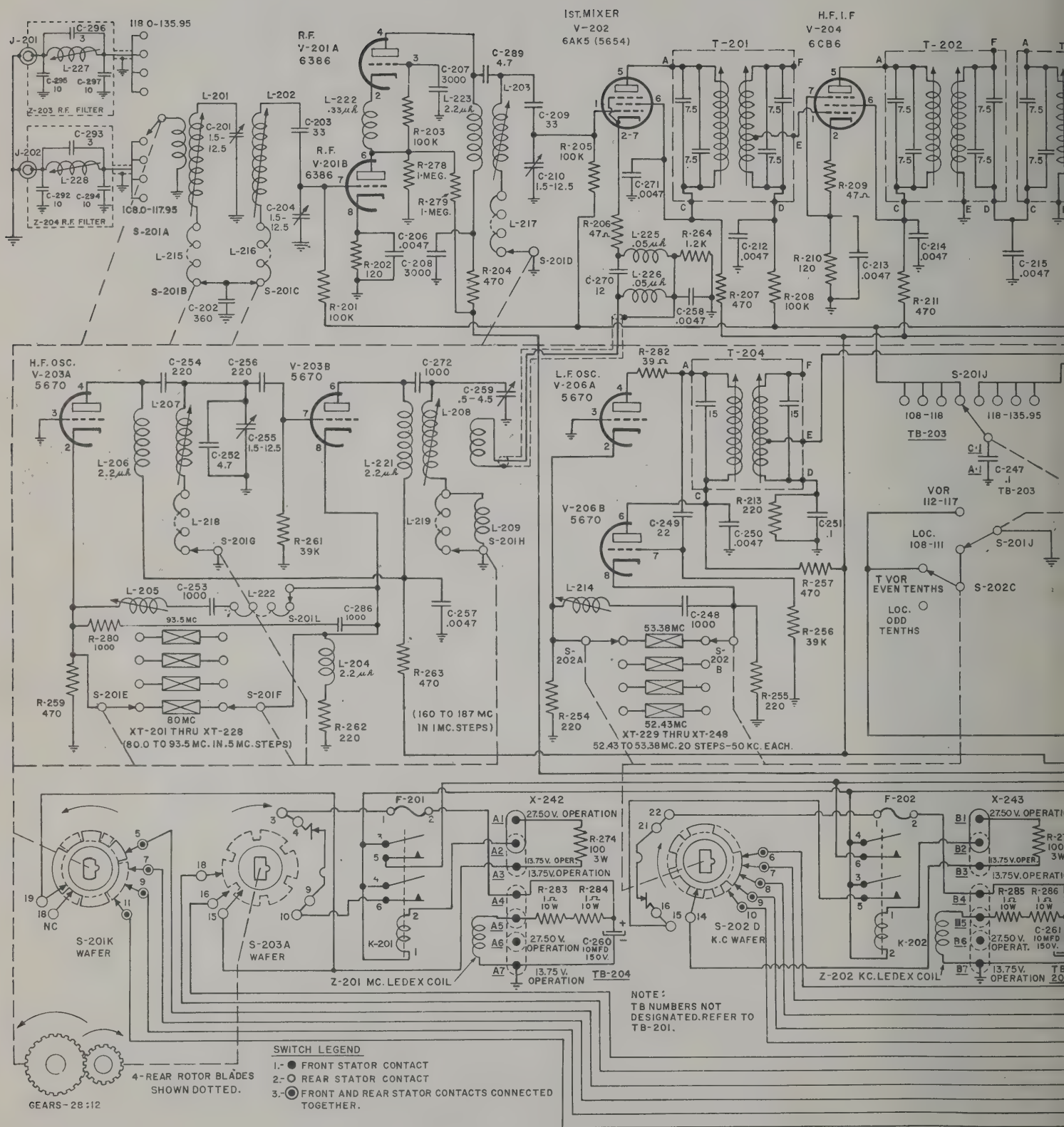
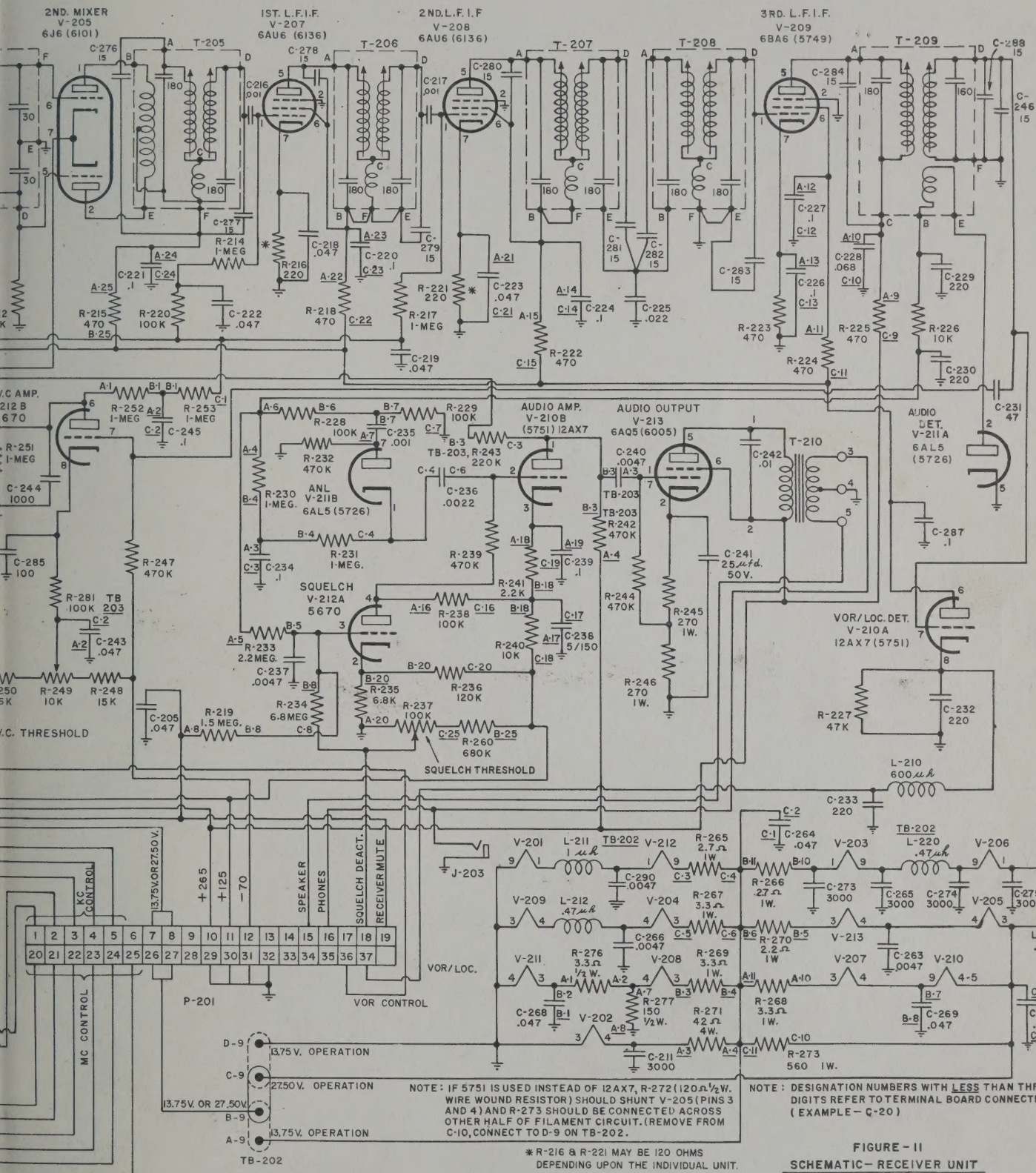


FIGURE-10
SCHEMATIC-TRANSMITTER UNIT


J-201
C-296
118.0-135.95
L-227
C-295
C-297
Z-203 R.F. FILTER
J-202
C-293
L-228
C-292
C-294
Z-204 R.F. FILTER
108.0-117.95
S-201A
L-201
L-202
C-201 1.5-12.5
C-203 33
C-204 1.5-12.5
L-215
L-216
S-201B
S-201C
C-202 360
R.F. V-201A 6386
R.F. V-201B 6386
L-222 .33μh
C-207 3000
L-223 2.2μh
R-203 100K
R-278 1-MEG.
R-279 1-MEG.
C-206 .0047
C-208 3000
R-202 120
R-201 100K
R-204 470
C-289 4.7
L-203
C-209 33
C-210 1.5-12.5
L-217
S-201D
1ST. MIXER V-202 6AK5 (5654)
R-205 100K
C-271 .0047
R-206 47Ω
L-225 .05μh
L-226 .05μh
C-270 12
R-264 1.2K
C-258 .0047
T-201
R-207 470
C-212 .0047
R-208 100K
H.F. I.F V-204 6CB6
R-209 47Ω
R-210 120
C-213 .0047
T-202
C-214 .0047
R-211 470
C-215 .0047
H.F. OSC. V-203A 5670
C-254 220
C-256 220
V-203B 5670
C-272 1000
C-259 .5-4.5
L-207
L-208
C-255 1.5-12.5
C-252 4.7
L-206 2.2μh
L-221 2.2μh
L-218
L-219
L-209
S-201G
S-201H
R-261 39K
L-205
C-253 1000
L-222
S-201L
C-286 1000
93.5MC
R-280 1000
C-257 .0047
L-204 2.2μh
R-263 470
R-259 470
S-201E
S-201F
80MC
R-262 220
XT-201 THRU XT-228
(80.0 TO 93.5 MC. IN .5 MC. STEPS)
(160 TO 187 MC IN 1 MC. STEPS)
L.F. OSC. V-206A 5670
R-282 39Ω
T-204
V-206B 5670
C-249 22
C-250 .0047
C-251 .1
R-213 220
R-257 470
L-214
C-248 1000
53.38MC
S-202A
S-202B
R-256 39K
R-255 220
R-254 220
52.43MC
XT-229 THRU XT-248
52.43 TO 53.38MC. 20 STEPS-50 KC. EACH.
S-201J
108-118
118-135.95
TB-203
C-247 .1
VOR 112-117
LOC. 108-111
T VOR EVEN TENTHS
LOC. ODD TENTHS
S-202C
F-201
X-242
27.50 V. OPERATION
R-274 100 3W
13.75 V. OPERATION
R-283 1Ω 10W
R-284 1Ω 10W
C-260 10MFD 150V.
TB-204
S-201K WAFER
S-203A WAFER
K-201
Z-201 MC. LEDEX COIL
S-202 D K.C WAFER
F-202
X-243
R-285 1Ω 10W
R-286 1Ω 10W
K-202
Z-202 KC. LEDEX COIL
NOTE: TB NUMBERS NOT DESIGNATED. REFER TO TB-201.
SWITCH LEGEND
1.- ● FRONT STATOR CONTACT
2.- ○ REAR STATOR CONTACT
3.- ◉ FRONT AND REAR STATOR CONTACTS CONNECTED TOGETHER.
4-REAR ROTOR BLADES SHOWN DOTTED.
GEARS-28:12



NOTE: IF 5751 IS USED INSTEAD OF 12AX7, R-272 (120Ω ½W. WIRE WOUND RESISTOR) SHOULD SHUNT V-205 (PINS 3 AND 4) AND R-273 SHOULD BE CONNECTED ACROSS OTHER HALF OF FILAMENT CIRCUIT. (REMOVE FROM C-10, CONNECT TO D-9 ON TB-202.

NOTE: DESIGNATION NUMBERS WITH LESS THAN THREE DIGITS REFER TO TERMINAL BOARD CONNECTIONS. (EXAMPLE – C-20)

*R-216 & R-221 MAY BE 120 OHMS DEPENDING UPON THE INDIVIDUAL UNIT.

FIGURE – 11
SCHEMATIC – RECEIVER UNIT

A - LF-OSC GRID
B - HF-OSC GRID
C - MIXER GRID
D - BUFFER AMP GRID
E - FINAL AMP GRID
F - FINAL AMP CATHODE
H - DIODE OUTPUT + SIDETONE
J - MOD. CATHODE